DOI:
10.1093/jcbiol/rux041

Document Version
Peer reviewed version

[Research note: revised R1 JCB-1821]

An amphidromic prawn, *Macrobrachium latimanus* (von Martens, 1868) (Decapoda: Palaemonidae), discovered on Pitcairn, a remote island in the southeastern Pacific

Robert A. Irving[1], Terence P. Dawson[2] and Daisy Wowor[3]

[1]Sea-Scope Marine Environmental Consultants, Dulverton, Somerset UK TA22 9PW;

[2]Department of Geography, Kings College London UK WC2R 2LS; and

[3]Division of Zoology, Research Center for Biology, Indonesian Institute of Sciences (LIPI), Jalan Raya Jakarta Bogor Km 46, Cibinong 16911, Indonesia

[*] Correspondence: R.A. Irving; e-mail: Robert@sea-scope.co.uk

(Received 5 December 2016; accepted xxxx 2017

ABSTRACT

The discovery of a population of *Macrobrachium latimanus* (von Martens, 1868) in a small pool on Pitcairn Island is a remarkable find, largely due to the island's isolation, the small size of the prawn, and the paucity of suitable freshwater habitat. As in many southeastern

Pacific islands, the volcanic origin of Pitcairn Island by geological activity at ‘hot spots’ through a pre-existing ocean floor, requires that their original colonization by the prawn must have resulted from long-distance dispersal. Like most carideans that live in freshwater and have small-size eggs, *M. latimanus* is an amphidromous species whose larvae are planktonic and must develop in a saline environment in estuaries and the open sea. After a period of some months in the marine environment, passing through many larval stages, the juveniles migrate upstream to the adult freshwater habitat. *Macrobrachium latimanus* has a widespread distribution throughout the Indo-West Pacific with Pitcairn Island, at 25°04'S, 130°06'W, now appearing to mark a new record for the southernmost and easternmost extent of its distribution.

Key Words: amphidromy, biogeography, Indo-West Pacific, Caridea

Pitcairn Island is one of four widely separated islands which constitute the Pitcairn Islands group, a British Overseas Territory in the southeastern Pacific. Pitcairn is the only inhabited island within the group and lies just south of the Tropic of Capricorn at 25°04′S, 130°06′W (Fig. 1). The island, barely 4.5 km^2 in area, forms the visible tip of an extinct volcano (highest point 347 m above sea level), which rises from the surrounding ocean floor at about 3,750 m depth (Irving & Dawson, 2012). The island’s topography consists of various peaks and ridges with steeply-sloping valleys in between, covered by low-growing trees and scrub, with much of its coastline bounded by high cliffs.

<*Fig. 1*>

There are very few permanent water bodies on Pitcairn and, with annual rainfall being less than 2,000 mm (Spencer, 1995), streams are ephemeral in nature. There are just a few areas where natural springs occur, the largest of which is known as Brown's Water, a shaded, damp area near the centre of the island at the edge of the scattered settlement of Adamstown. There is also an ephemeral stream known locally as the Pools (barely a trickle during dry periods), which runs northwards down Water Valley, Tedside, on the northwestern side of the island. It is within a small pool of this latter stream (possibly known as Mama's Pool, though this has been difficult to confirm, but referred to here as simply 'the prawn pool') that the prawn was found (Fig. 2). Just two individuals were seen during the visit of RAI and TPD on 7 September 2011; the total length (TL) of the larger being approximately 80 mm. The presence of the prawn within this particular pool on Pitcairn had been known by islanders for some time, although its scientific identification had remained a mystery up until now.

<Fig. 2>

No specimens were collected due to the apparent very small size of the population. One of the authors (DW) can confirm their identity with confidence by close inspection of photographs taken at the time (Fig. 3). The prawn in the net has a subcylindrical body form. The rostrum is short, reaching the mid-line of the third segment of the antennular peduncle, but never reaching the distal border of the scaphocerite; it is moderately deep and both dorsal and ventral carinae are convex. One tooth is completely postorbital with a total of 7 teeth on the dorsal carina and 3 teeth on the ventral carina. The second pereiopod pair are robust, similar in shape, unequal in size and rather flat (oval in cross-section); the carpus is cup-shaped, shorter than the chela and the merus. These are all specific characters of *Macrobrachium latimanus* (von Martens, 1868).

<*Fig. 3*>

Macrobrachium latimanus has a widespread distribution throughout the Indo-West Pacific region. Its range extends from India and Sri Lanka in the west, throughout the Malay Peninsula an Indonesia to the Ryukyu Islands in the northwestern Pacific and to the Marquesas Islands in the east. It is also present within other island groups of eastern Polynesia, namely the Society Islands (Moorea, Tahiti), the Austral Islands (Rurutu, Tubuai), and the Gambier Islands (Mangareva) (Marquet, 1991; Poupin, 1998; Keith *et al*., 2013) of French Polynesia. This species most frequently occurs in rivers and streams, with adults being found in habitats up to 1,300 m in altitude, as well as in lowland rivers (De Grave *et al*., 2013). It is reported to be common in the upper reaches of streams in French Polynesia (Marquet, 1991; Fossati & Danigo, 1995). In India and Sri Lanka it is known as the 'mountain river prawn' (Tiwari, 1961), though in the Cook Islands it is called the 'thick claw prawn' (Cook Islands Biodiversity Database, 2007).

As an amphidromous species, *M. latimanus* spends a part of its life history in a saline environment. This species has small-sized fertilized eggs and the adults are found in freshwater, but they migrate to marine environments for spawning (Wowor *et al.*, 2009). The small eggs give rise to free swimming larvae that are euryhaline and go through 11 zoeal and one decapodid stages before becoming bottom-dwelling juvenile stages (Ito *et al*., 2006). Thereafter the post-larvae move upstream into freshwater habitats. Like other amphidromous species, *M. latimanus* spends most of its time feeding and growing in freshwater to reach its adult form, eventually reproducing again (Bauer, 2013; McDowall, 2007).

The larvae of *M. latimanus* are euryhaline; in the laboratory, they have been studied in aquaria with a water salinity of 17.5 ppm during the first zoea stage, and of 28.0 ppm during subsequent larval stages (Ito *et al*., 2006). Due to the physiological requirements of the

larvae, their development continues in fully saline water such as the open sea. The larvae are planktonic so they will be carried by sea currents to other areas. They spend up to 107 days (3.5 months) at sea before reaching the juvenile stage (Ito *et al*., 2006), providing an opportunity to be transported long distances.

How *M. latimanus* would have arrived at Pitcairn Island, and from where, is a matter of conjecture. There appear to be two possibilities. The trade winds at inter-tropical latitudes normally cause the water masses in the Pacific Ocean to flow from east to west, the South Equatorial Current (SEC) (Jarrige, 1968). The water accumulating in the west then tends to flow back towards the east, taking routes where the winds are light or variable, and these reflux movements are known as the Equatorial Counter-Currents (ECC). The most southern of these, the South Equatorial Counter Current (SECC) provides for a west-east connectivity between French Polynesia and Pitcairn Island (Eldin, 1983). There is a well-defined eastward flow at around 9°S between longitudes 135°W and 169°W, suggesting that the prawn's presence at Pitcairn might originate from the Marquesas Islands (located at 9°00'S, 139°30'W). The larvae could have initially been transported eastwards on the SECC, then carried southwest to Pitcairn Island on the SEC. Those islands lying further to the south, however, are less likely to be influenced by these major currents. So far, the most easterly extent of the distribution of *M. latimanus* has been at Mangareva Island (23°06'S, 134°58'W) in the Gambier Islands; and the most southerly extent has been at Tubuai Island (23°23'S, 149°27'W) in the Austral Islands of French Polynesia (Marquet, 1991). The fact that the Gambier Islands lie some 450 km to the west-northwest of Pitcairn Island and that the vast majority of the Pitcairn Islands' marine biota has derived from the west (Kay, 1984; Diamond, 1995; Irving & Dawson, 2012), raises the possibility of the larvae of *M. latimanus* reaching Pitcairn Island (25°04'S, 130°06'W) from the Gambier Islands. The prawn's

discovery on Pitcairn Island becomes the southernmost and the easternmost distribution record for this species.

The late stage larvae or early stage juveniles eventually reach the mouth of the small freshwater stream on the northwest coast of the island. At this time, the juveniles of *M. latimanus* require freshwater in order to complete their development. Upon entering the stream, they continue swimming against the current until they reach the pool which lies approximately 100 m above sea level and about 200 m from the coast. It would appear they then grow to young adults within this pool, as were encountered by the first two authors in September 2011.

It is well known that *M. latimanus* inhabits true freshwater habitats, both lentic and lotic water bodies, in high volcanic islands (Marquet, 1991). Whilst Pitcairn is the only volcanic island amongst the Pitcairn group of islands, it has very few freshwater habitats, the main two being the prawn pool at Tedside and Brown's Water on the fringes of Adamstown, with *M. latimanus* only being found in the prawn pool (Fig. 2). There are no freshwater sources in the other atoll islands of the Pitcairn Islands and hence *M. latimanus* and other species belonging to the genus *Macrobrachium* are absent on those islands.

The long-term survival of this small prawn population on Pitcairn remains uncertain. A recently commenced infrastructure project, involving the building of a new jetty and an access road along the top of the shore where the stream emerges at the coast, may well have an adverse impact on the emergence of the stream where it encounters the sea. As the prawn's identification and its complex lifecycle were not known at the time this construction project commenced, we are not aware of any mitigating measures which may have been taken to allow for the continued natural flow and emergence of the stream.

The presence of *M. latimanus* on such a small island with next to no flowing or standing water is remarkable. The extended planktonic larval stages of this amphidromous

shrimp are clearly responsible for its widespread distribution throughout the Indo-West Pacific region. It is currently considered by the IUCN as being of 'Least Concern' worldwide for conservation purposes (De Grave *et al*., 2013). On Pitcairn, however, the very small size of the population, the limited size of the water body in which they live, and the possible disruption to their route to and from the sea, all indicate they should be regarded as being vulnerable or even endangered at the very least.

ACKNOWLEDGEMENTS

The authors would like to thank Kerry Young and Heather Menzies, residents of Pitcairn Island, for guiding them to the pool in September 2011. The two anonymous referees are thanked for their helpful comments on the first draft of the manuscript.

REFERENCES

Bauer, R.T. 2013. Amphidromy in shrimps: a life cycle between rivers and the sea. *Latin American Journal of Aquatic Research*, **41**: 633–650.

Cook Islands Biodiversity Database, 2007. The Cook Islands Natural Heritage Trust [http://www.cookislands.bishopmuseum.org].

De Grave, S., Cai, X. & Wowor, D. 2013. *Macrobrachium latimanus*. The IUCN Red List of Threatened Species 2013: e.T197897A2504238 [http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T197897A2504238.en].

Diamond, J. 1995. Introduction to the exploration to the Pitcairn Islands. *Biological Journal of the Linnean Society*, **56**: 1–5.

Eldin, G. 1983. Eastward flows of the south equatorial central Pacific. *Journal of Physical Oceanography*, **13**: 1461–1467.

Fossati, O. & Danigo, H. 1995. A new sampling method for freshwater shrimps. *Mesogee*, **54**: 43–48.

Irving, R.A. & T.P. Dawson. 2012. The marine environment of the Pitcairn Islands. Global Ocean Legacy Project, Pew Environment Trusts/Dundee University Press, Dundee, UK.

Ito, A., Fujita, Y. & Shokita, S. 2006. Complete larval development of *Macrobrachium latimanus* (Von Martens, 1868) (Decapoda: Caridea: Palaemonidae) reared under laboratory conditions. *Crustacean Research*, **35**: 1–26.

Jarrige, F. 1968. On the eastward flow of water in the Western Pacific South of the Equator. *Journal of Marine Research*, **26**: 286–289.

Kay, E.A. 1984. Patterns of speciation in the Indo-West Pacific. In: Biogeography of the tropical Pacific (F.J. Radovsky, P.H. Raven & S.H.Sohmer, eds). *Bernice P. Bishop Museum Special Publication*, **72**: 15–31.

Keith, P., Marquet, G., Gerbeaux, P., Vigneux, E. & Lord, C. 2013. Poissons et crustacés d'eau douce de Polynésie: taxonomie, écologie, biologie et gestion. Freshwater fish and crustaceans of Polynesia: taxonomy, ecology, biology and management. Société Française d'Ichtyologie, Paris.

Marquet, G. 1991. Freshwater crustaceans of French Polynesia: taxonomy, distribution and biomass (Decapoda). *Crustaceana*, **61**: 125–140.

McDowall, R.M. 2007.On amphidromy, a distinct form of diadromy in aquatic organisms. *Fish and Fisheries*, **8**: 1–13.

Martens, E. von, 1868. Ueber einige ostasiatische Süsswasserthiere. *Archiv für Naturgeschichte*, **34**: 1-64, pl. 1.

Poupin, J. 1998. Crustacea: Decapoda and Stromatopoda of French Polynesia. *Atoll Research Bulletin*, **451**: 1–62.

Spencer, T. 1995. The Pitcairn Islands, South Pacific Ocean: plate tectonic and climatic contexts. *Biological Journal of the Linnean Society* (London), **56**: 13–42.

Tiwari, K.K. 1961. Occurrence of the freshwater prawn *Macrobrachium latimanus* (Von Martens) in India and Ceylon. *Crustaceana*, **3**: 98–104.

Wowor, D., Muthu, V., Meier, R., Balke, M., Cai, Y. & Ng, P.K.L. 2009. Evolution of life history traits in Asian freshwater prawns of the genus *Macrobrachium* (Crustacea: Decapoda: Palaemonidae) based on multilocus molecular phylogenetic analysis. *Molecular Phylogenetics and Evolution*, **52**: 340–350.

Figure legends

Figure 1. The scattering of main island groups in the southeastern Pacific Ocean. Insert: Pitcairn Island and the other three islands of the Pitcairn Islands group within their EEZ in relation to Mangareva, the nearest island of the Gambier Island group, French Polynesia.

Figure 2. Pitcairn Island, showing the location of the 'prawn pool' (X). Insert: photo of the 'prawn pool' in September 2011 (photo: R.A.I.).

Figure 3. An adult *Macrobrachium latimanus* from the 'prawn pool', Pitcairn Island in September 2011. Insert: rostrum of the adult *M. latimanus* (photos: R.A.I).

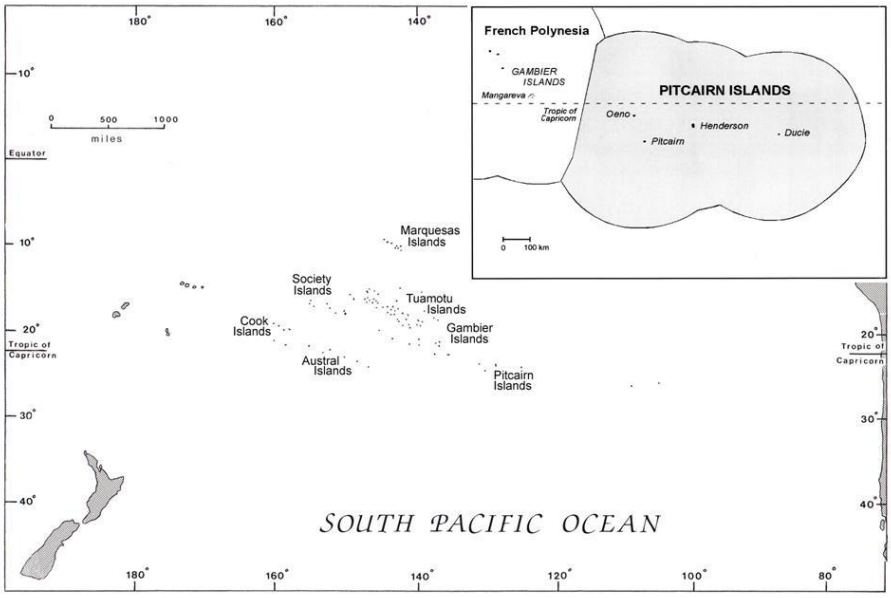

Figure 1. The scattering of main island groups in the southeastern Pacific Ocean. Insert: Pitcairn Island and the other three islands of the Pitcairn Islands group within their EEZ in relation to Mangareva, the nearest island of the Gambier Island group, French Polynesia.

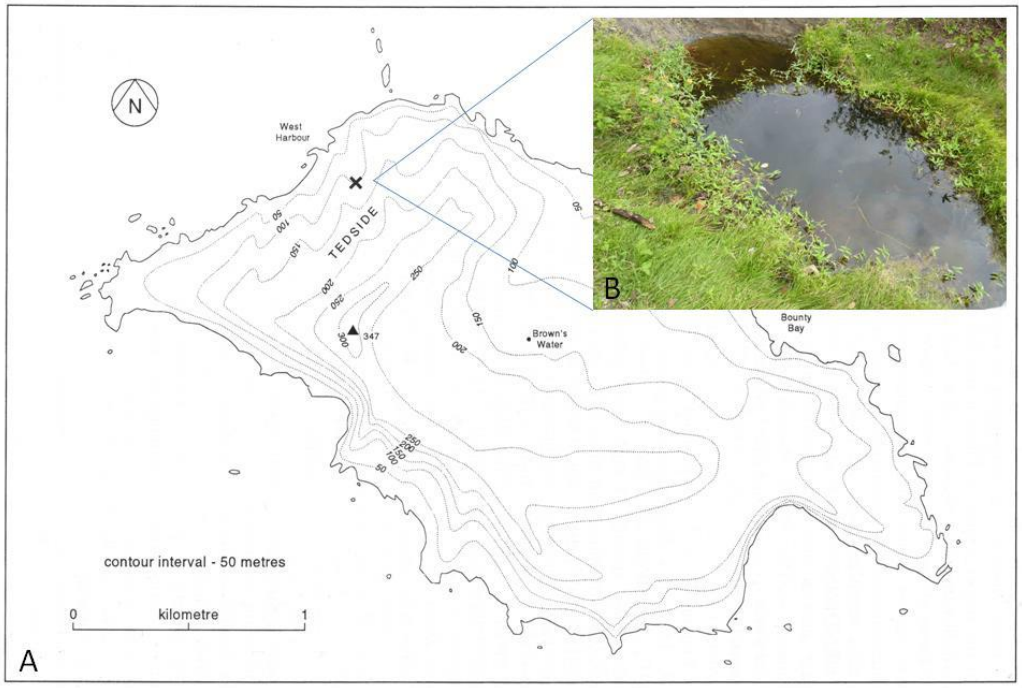

Figure 2. Pitcairn Island, showing the location of the 'prawn pool' (X). Insert: photo of the 'prawn pool' in September 2011 (photo: R.A.I.).

Figure 3. An adult *Macrobrachium latimanus* from the 'prawn pool', Pitcairn Island in September 2011. Insert: rostrum of the adult *M. latimanus* (photos: R.A.I).